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Agricultural Research

Bio-engineered Barley

Story on page 4

From Apples to Zucchini—Biotechnology for Agriculture

The research community is today 10 years into what will likely be a 20-year experiment aimed at understanding the workings of informational molecules that carry plant genetic codes.

During these 20 years, we may answer the questions of how plants develop and how we can best use genetics, molecular biology, biochemistry, and traditional plant breeding to increase yields and develop products that add value to agricultural crops.

The blending of these diverse—though related—sciences and cultures is critical for success. And I believe the resulting "hybrid vigor" will be recorded in productivity, both in the field and in commerce.

Molecular biology during the 1970's first enabled scientists to isolate and manipulate essentially any segment of DNA from any organism. Several plant genes had already been studied at that level, and compelling evidence indicated that all plant genes would one day prove accessible to recombinant DNA technology.

By 1980, the horizon was ablaze with enthusiasm for the potential applications of biotechnology for agriculture. This emerging technology appeared to offer unparalleled opportunities.

But those early-1980 expectations for short-term benefits to American agriculture from biotechnology have to be described as outrageous. Venture capital and corporate dollars were flowing at an unprecedented rate, to provide the agricultural business sector with opportunities for a technology that was then largely theoretical. Both experience and actual applications to even the most simple plant genes were virtually nonexistent.

Gene manipulation—even at the level of DNA—does not necessarily lead to an understanding of gene structure, organization, function, and expression in a crop plant. Thus, model biological systems had to be developed so that the functions of isolated DNA bits could be assayed in a whole plant.

And the enormous early expectations for the application of DNA technology to production agriculture led to a number of grave concerns among many plant biotechnologists—concern due to the recognized complexity of the plant genome; concern for the lack of documented experience and success in this field of biology; concern that the high expectations would not be met and corporate enthusiasm would wane; and concern that a lack of long-term interest would lead to missed opportunities.

Indeed, history has borne out the seriousness of those concerns. Only a small number of agricultural venture capital corporations have survived. Corporate managers have transferred their attention and their investment to other areas of investigation. The deluge of short-term recombinant DNA products that was promised hasn't yet inundated plant agriculture.

Also, in 1980, uncertainties regarding regulatory agency control of recombinant molecules released into the environment appeared to be a major obstacle. We are just now beginning to understand what kinds and degrees of oversight will be needed, with USDA, EPA, and FDA in position to address societal and scientific agendas.

So it has been that, over a decade, the projected adjustment of enthusiasm for agricultural biotechnology has occurred. During that time, great experience was gained through a steady, productive, realistic pursuit of this new technology.

Researchers, both public and private, moved at what is really a dazzling rate in plant agriculture to produce an ever-increasing, high-quality literature based on experience. The impact of molecular genetics is being seen in this expanding body of knowledge.

Thus far, researchers have reported genetically engineering more than 40 crops. This impressive list spans the agricultural lexicon from A through Z and includes apples, barley, broccoli, cabbage, carrots, coffee, corn, cotton, grapes, lettuce, oilseed rape, peas, potatoes, raspberries, rice, soybeans, strawberries, sugar beets and sugarcane, sunflowers, tobacco, tomatoes, wheat, and zucchini.

As practitioners of science for agriculture we must continue to lay the foundation with today's experiences to realize tomorrow's expectations.

Gerald G. Still
Director (1983-1993)
Plant Gene Expression Center

Agricultural Research

Cover: Scientists at the ARS/University of California Plant Gene Expression Center are the first in the world to report success in genetically engineering barley. Some of the bioengineered barley carries a gene that may help the plants resist attack by barley yellow dwarf virus. Photo by Jack Dykinga. (K5141-4)

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Can Better Barley Be Bred?

Consortium members pursue this and other crop improvements.

Fragrant, great-tasting bread made from an unusual ingredient—barley flour—may appear on tomorrow's supermarket shelves. Biotechnologists at the ARS/University of California Plant Gene Expression Center in Albany have paved the way for this and other futuristic innovations with the healthful grain.

They've done it by refining tactics needed for inserting new, useful genes into barley.

Today's barley won't make flour that would yield raised loaves. Tomorrow, however, genes needed to do this could be moved into barley, following laboratory techniques hammered out in the center's experiments.

The barley biotech team of Peggy G. Lemaux and Yuechun Wan is the first in the world to report a method to genetically engineer the crop. The genes Lemaux and Wan inserted may help barley resist attack by barley yellow dwarf virus. The researchers are now scrutinizing genes that might make a rich, nut-flavored barley bread—leavened without the help of wheat flour—a reality.

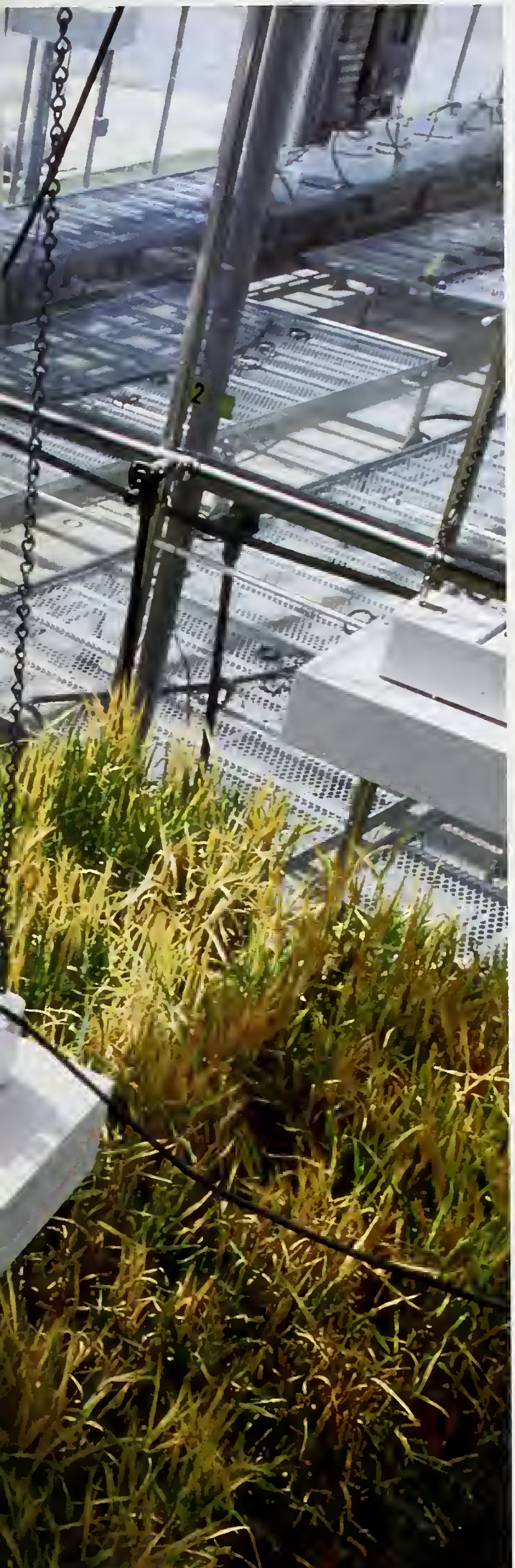
Established in 1984, the Plant Gene Expression Center is a joint venture of the U.S. Department of Agriculture's Agricultural Research Service, the University of California at Berkeley, and the California Agricultural Experiment Station. The barley project is one of the newest in which the center has combined outside financing (in this case, funds from brewery giant Coors) with the talent of University of California researchers (Lemaux and Wan) to pursue exceptionally difficult scientific ventures.

Another bioengineering expedition, newly launched, may yield tomatoes that rely heavily on their naturally occurring, microscopic leaf hairs to repel, trap, or kill insect enemies.

That could "eventually reduce the need for insecticides," says researcher Sheila M. Colby. She won a USDA

JACK DYKINGA

Yuechun Wan (left) and Peggy Lemaux harvest kernels from genetically engineered barley plants. Collaborators elsewhere will assess resistance to barley yellow dwarf virus in test plants grown from these kernels. (K5140-4)



National Research Initiative Competitive Grant to begin pursuing this intriguing possibility in Lemaux's laboratory at the center. The undertaking also garnered special ARS funds awarded for studies of new ways to stop the sweetpotato whitefly—a nemesis of tomatoes, cotton, alfalfa, and other crops.

Both the barley and the tomato enterprises supplement the center's ongoing plant molecular biology work. They showcase the center's aggressive policy of tapping uniquely qualified researchers and new sources of funds to work on tough, short-term projects. "We consider this our 'consortium concept' even though it's a bit different from the traditional idea of a permanent roundtable of consortium partners," says former center director Gerald G. Still.

"We use just about every option available for these special projects, from research agreements arranged locally to CRADA's—Cooperative Research and Development Agreements that are negotiated nationally by the ARS Technology Transfer office.

"We also use a memorandum of understanding and informal agreements with universities and ARS research labs in about a half-dozen states. Their researchers either work with us off-site or come here for however long it takes to get a job done.

"We have a string of successes that we credit to the consortium concept. We were among the first to insert new genes into corn, a troublesome grain to bioengineer. *[See box at right.]* We attracted funding from Cotton Incorporated to genetically engineer cotton so it won't be killed by accidental drift of chemicals from neighboring fields. Now we've bioengineered barley.

"The consortium concept has meant drawing up interim groups that act like scientific SWAT teams—they come in, do a job, then hand the work to others

Corn Genetic Engineering Expanded

A new shortcut may hasten genetic engineering of America's leading commercial varieties of corn, reports Yuechun Wan of the Plant Gene Expression Center. With a gene gun, Wan inserted new genes into laboratory clusters of corn cells called Type I callus, then prompted them to form corn plants with the new genes working inside. So far, she's produced more than 200 healthy, fertile plants.

That's good news for researchers trying to bioengineer corn, because most of the nation's top varieties form Type I callus in laboratory petri dishes. Clumps of callus resemble cream of wheat.

Until now, biotechnologists hadn't been able to move new genes directly into Type I callus with a gene gun, an instrument that shoots microscopic, gene-coated metal particles into waiting cells.

Wan's approach may speed experiments by eliminating the need for time-consuming crosses. In the past, bioengineers' only practical alternative was to move new genes into Type II corn callus cells. When a gene expression center team succeeded in genetically engineering corn in 1990, for example, they had to rely on Type II callus.

But corn varieties that form Type II callus aren't commercially important. That meant breeders must cross bioengineered Type II corn plants with top-performing commercial varieties. The process can take several years.

Corporate and university agricultural biotech teams are interested in Wan's streamlined technique. She plans to publish the method this year.—**Marcia Wood**, ARS.

JACK DYKINGA

Former director of the Plant Gene Expression Center Gerald Still inspects genetically engineered barley created in one of the center's public/private consortium projects. (K5142-1)

to carry forward. For us, this works really well."

Here's a closer look at how these special-assignment researchers envision tomorrow's barley and tomato plants.

Agricultural biotechnologists have tried for nearly a decade to coax barley to accept new genes. Lemaux and Wan succeeded late last year. Their winning strategies included using barley embryos—bits of tissue about the size of a pinhead. They removed the embryos from still-green kernels, then shot them with tiny gold bullets. Each bullet was coated with genes that scientists expect will fight barley yellow dwarf virus.

To propel the bullets, they used a helium-powered gene gun—a self-contained device that's about the size of a large box of laundry detergent. "When you flip a switch," Lemaux says, "the gun drives the bullets into the cells so the new genes can become part of the cells' genetic makeup."

Wan pinpointed cells from the embryos that had taken up the new genes, then nurtured them into healthy, fertile plants in the greenhouse. "Our approach is very efficient," notes Wan, who produced hundreds of bioengineered barley plants in only 7 months.

The genetically engineered plants boast a borrowed gene that may make them resistant to barley yellow dwarf virus. Transmitted by aphids, this virus weakens plants and lowers yields. It ranks among barley's five worst disease enemies.

Virologists Steven Wyatt at Washington State University and Richard Lister, Purdue University, provided the antiviral genes.

SHEILA COLBY

A cross-section of a leaf from wild tomato, *Lycopersicon hirsutum*, shows chemical-releasing leaf hairs, or trichomes, on the top and underside. (Magnified about 115 times. K5914-1)

The Albany researchers intend to examine other resistance genes. "The virus might figure out a way to get around plants that have only single-gene resistance," Lemaux says. "When we have other new genes for resistance, they can be engineered into separate plants that can then be crossed with each other. Their offspring might inherit resistance genes from both parents. That would give these new plants multiple sources of resistance that the virus would have a harder time beating."

Too, the biotech plants will be bred with plants containing a natural resistance gene, *Yd2*. Since the 1950's, barley breeders have known *Yd2* as a source of barley yellow dwarf resistance that they could introduce into commercial varieties.

But *Yd2's* protection is limited, partly because it primarily targets only one of the five strains of the virus.

Developing CRADA's

To accelerate commercialization of research, the Agricultural Research Service has signed more than 300 CRADA's—Cooperative Research and Development Agreements—with corporate partners worldwide during the past 7 years.

Arranged through ARS' Office of Technology Transfer, these agreements can give industry partners the first option for exclusive licenses on patented inventions or plant varieties made under the CRADA. Licenses may generate royalties and other income for both ARS inventors and the agency.

More information is in the March 1992 leaflet, "Technology Transfer Agreements With the Agricultural Research Service."

For a copy, contact Willard J. Phelps, USDA-ARS, Room 419, Bldg. 005, BARC-West, 10300 Baltimore Ave., Beltsville, MD 20705-2350; phone (301) 504-6532, fax (301) 504-5060.

Crossing *Yd2* plants with bioengineered ones may supplement resistance, says Phil Bregitzer of the ARS National Small Grains Germplasm Research Facility in Aberdeen, Idaho.

He'll coordinate that work, as well as this summer's outdoor tests in California, Idaho, and Illinois.

In the field experiments, plants with only *Yd2* protection will be pitted against bioengineered barley, to compare resistance.

Meanwhile, Lemaux's other scheme for barley—to explore its potential for making a novel bread dough—is a consortium venture with Bob B. Buchanan, a University of California scientist, and Karoly Kobrehel, a French government researcher. Experiments by Buchanan and Kobrehel showed that thioredoxin, a plant protein, dramatically improves the volume, height, and elasticity of wheat breads, making light, fine-textured loaves. Bioengineering barley's genes for thioredoxin and related proteins might prove key to making leavened loaves from barley flour.

Barley bread would open a new market for a grain that today is used primarily for malting and in animal feed. And this innovative use of the grain might lessen some countries' reliance on wheat. "Barley can outproduce wheat by as much as 35 bushels per acre, under some conditions," comments Still. "In some climates that are too harsh for wheat, barley will thrive."

Leaf Hairs Defend Plants

View a tomato leaf under a microscope and you'll see a forest of miniature hairs. Some look like spikes; others resemble tiny mushrooms. These are trichomes (pronounced TRY-komes), tiny projections that have fascinated scientists for nearly a hundred years.

Researchers don't yet understand exactly how each different type of trichome works. Nevertheless, they do know that those equipped with glands emit natural chemicals. Scientists surmise that the sticky sugars emitted by some trichomes act like flypaper to catch unsuspecting insects. Other trichomes secrete compounds that may repel or poison insects.

"Some of these gland-produced compounds are monoterpenes—aromatic chemicals that give kitchen herbs like sage, thyme, and mint their pleasant scent," says researcher Sheila Colby. She's hunting for the genetic switches that cue tomatoes to manufacture the aromatic compounds in trichomes.

Colby is collaborating with Anthony Waiss of the ARS Western Regional Research Center in Albany. He's an authority on protective chemicals manufactured by tomato, citrus, soybean, and other crops.

"Once we identify the switches and understand how they work," says Colby, "we may be able to change what is made in the trichomes. Compounds produced by genetically engineered trichomes might someday give tomato plants more robust resistance to insect enemies like whiteflies or tomato hornworms. The same strategy may improve insect defense for other trichome-bearing plants as well."—By **Marcia Wood,** ARS.

JACK DYKINGA

Yuechun Wan of the Plant Gene Expression Center selects pieces of barley tissue that have been bombarded by a gene gun. (K5140-18)

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SCOTT BAUER

The Busiest of Bees

Pollen bees outwork honey bees as crop pollinators.

The bee had landed on the ground, ready to walk into its nest in the soil, when Suzanne Batra reached for it, gently taking hold of it between her fingers.

"What do you think it smells like?" she asks, holding it up like a freshly picked flower. "Smells like lemon, doesn't it?"

She explains that it's actually a fragrance blend of three chemicals that the bees use to attract each other. "Each kind of bee has its own special odor. Some smell like fruit, flowers, or rubber; others smell like dirty socks or skunks," she says.

Then she puts the bee down, and it ambles away, headed back home to its underground, plastic-lined nest. These native pollen bees are known as polyester bees, because they produce their own transparent, polyester plastic to line their cells and keep them dry.

"They're very gentle," she says of pollen bees. "They rarely sting, and most don't even store honey. They're not what you think of when you think about bees, are they?"

Not at all. They certainly don't fit descriptions of the Africanized honey bees that have captured headlines as "killer bees" because of their aggressive behavior and propensity to sting. And they are not hornets or yellowjacket wasps, which are sometimes mistakenly called bees. Instead, pollen bees go by friendlier names, such as digger, sweat, bumble, hornfaced, carpenter, leafcutter, orchard, and shaggy fuzzyfoot.

"You can tell it's a bee if it's on a flower collecting pollen on its hind legs or under its stomach," Batra says. "Wasps and hornets visit flowers and eat nectar, but they don't collect pollen."

Pollen bees are like family to Batra, who for more than 20 years has studied their behavior and advocated them as nature's hardest-working, most effective crop pollinators. She wants backyard gardeners, commercial fruit growers, and everybody else to treat them like useful pets, making places for them to nest and minimizing the use of pesticides that can harm them.

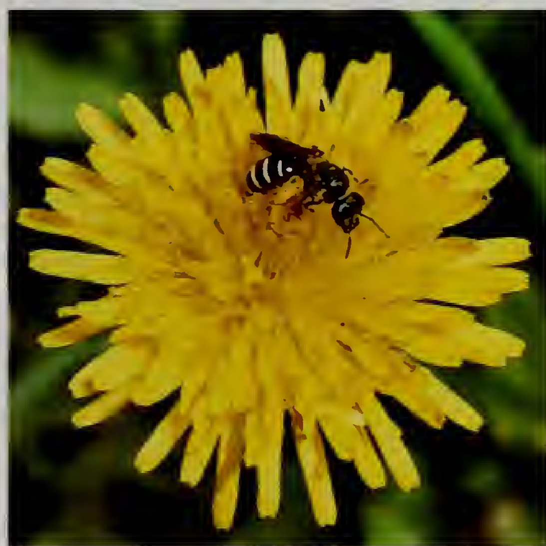
"I've spent my whole career trying to educate people about pollen bees," she says, surrounded by Styrofoam coolers, adobe, and other materials that she's made into homes for them. "People need to realize there are a lot of valuable bees out there that they are unaware of because they don't look like honey bees. Without them, crop and wildflower pollination would really suffer."

◀ **Entomologist Suzanne Batra collects polyester bees, which release a lemony odor (pheromone) from their mouths that attracts more bees to the net. (K5397-5)**

Of the more than 20,000 known bee species, only six are honey bees (genus *Apis*). The rest are pollen bees, also called solitary or wild bees.

There are about 3,500 kinds of pollen bees in North America. A good example of the mix of honey and pollen bees in a typical natural habitat is illustrated in a 3-year study that Batra and a cooperator at Georgetown University are conducting in the Fernow Experimental Forest in West Virginia. In 1991—the first year of the study—they randomly trapped 1,701 pollen bees, but only 34 honey bees. They found similar mixes during 1992 and 1993.

SCOTT BAUER



Sweat bees: Small wild bees such as this one visiting a dandelion are often attracted by salty sweat on hot days. (K5397-14)

"Most of the pollen bees were bumble, sweat, and digger bees," she says. "People would not realize that the tiny ones are bees." That's partly because they don't act like the familiar honey bee. Pollen bees usually don't sting—and if they do, it's usually mild, something akin to a mosquito bite. "If you disturb a honey bee colony, the bees will attack and sting you," Batra says. "But you can open most pollen bee nests, and they won't defend them."

Batra says the differences in behavior are largely evolutionary. Honey bees, as social insects with thousands of residents per colony, store large amounts of honey—an inviting target for sweet-toothed animals like bears.

Consequently, honey-bee stings are potent enough to drive away animal invaders. The social bumblebees and tropical stingless bees also store food and vigorously defend their colonies. Stingless bees bite and release a saliva chemical that irritates the skin.

Most pollen bees nest in the ground, where animals have a hard time finding them. The solitary pollen bees only have one female to a nest, meaning there isn't much food on hand for invaders to covet. "Some social sweat bees might have a few dozen bees per colony," she says, "but even then there's not enough food in their small underground nests to make an inviting target. So they really haven't needed to develop potent venom or aggressive stinging behavior."

If you think bears hibernate for long periods, consider pollen bees. Most kinds are dormant for 10 to 11 months a year, living as larvae or pupae inside the nests they build in the ground, in twigs, hollow tree branches, or in the types of artificial nests that Batra builds outside her Beltsville, Maryland, lab and even in her own backyard.

EDWARD McCAIN

Buzz pollinator: Entomologist Steven Buchmann observes a giant carpenter bee, which uses rapid vibrations to release pollen. (K5401-1)

But when the adult pollen bees emerge—many flying for only 4 to 6 weeks in the spring—they go about pollinating with the energy of a salmon swimming upstream to spawn.

Hornfaced and Fuzzyfoot

"There are certain crops, like alfalfa, blueberries, apples, tomatoes, and potatoes, that honey bees just don't pollinate well," she says. "Some of the pollen bees are specialized for these."

Take the hornfaced bee. Used commercially for several decades in Japan, the popularity of the hornfaced among apple growers has grown considerably. By 1990, it was used to pollinate more than 60 percent of the apples grown in a major apple-growing region in northern Japan.

Based on work done, it's easy to see why it has become so popular. A single hornfaced bee can visit 15 flowers a minute, setting 2,450 apples in a day—compared to the 50 flowers set in a honey bee's day. Batra says that in Japan, apple growers only need about 500 to 600 hornfaced bees per hectare (2.47 acres). That same grower would need thousands of honey bees to pollinate the same area.

Since an earlier story on wild bees ["Wild Bees Make Money Not Honey," *Agricultural Research,* August 1987, pp. 10-12.], Batra says she has sent hornfaced bees to beekeepers, orchardists, and others in several states. Most U.S. growers still rent honey bees from beekeepers. However, that could change as beekeeping becomes more difficult and expensive because of new honey bee diseases, mites, and quarantines due to Africanized honey bees, and the phase-out of federal honey subsidies.

"Growers may have to get more and more into raising their own bees. Pollen bees will become more attractive then, because they are efficient pollinators, gentle, and easy to keep," she says. This has already happened with commercially available alfalfa leafcutter bees.

The newest addition to Batra's wild bee family is the "shaggy fuzzyfoot" bee. This fat, shaggy, fast-flying bee carries pollen back to the nest on its fuzzy hind legs, she says, and can be heard buzz-pollinating blueberries. In that type of pollination, the bee creates a vibration that releases the pollen from inside tiny, tubelike anthers. It's a feat that honey bees can't accomplish, because they don't vibrate their bodies to shake pollen loose.

Batra has been studying the shaggy fuzzyfoot since 1988, when she received permission to import a few from Japan to study at Beltsville. Batra found the bees in the adobe walls of an old farmhouse in Japan during a research trip there and was impressed with their ability to pollinate in rain and cold, when other kinds of bees would not.

Now she has 400 nests in Beltsville, and is planning to release some shaggy fuzzyfoots to growers who want to use them to pollinate orchards in the southeastern states.

Fuzzyfoots pollinate blueberries, apples, and other crops for only 6 weeks in the spring—but it's a busy 6 weeks, during which females lay eggs and seal their mud cells inside Batra's handmade adobe blocks. Bee larvae grow inside during summer, pupate in the fall, become adults, and hibernate in the cells over winter. They're best adapted for a moist, warm climate and can survive mild winters.

Blueberries aren't the only crop suited to pollen bees. Tomatoes, chili peppers, eggplants, and cranberries have similar flower structures that require

SCOTT BAUER

◀ **Plasticized: A polyester bee emerges from its burrow in spring. These bees protect their nectar, pollen stores, and delicate broods by lining their cells with waterproof, transparent polyester plastic secreted by two of the female's glands and mixed by her, like an epoxy glue. (K5398-20)**

▶ **Ace blueberry pollinator: *Osmia ribifloris* bees are three times faster than worker honey bees. Here, entomologist Phil Torchio inspects adults as they emerge from cocoons extracted from nests produced the previous year during blueberry pollination studies. (K5399-1)**

JACK DYKINGA

buzzing bees for effective pollination, says Stephen L. Buchmann, an entomologist at ARS' Carl Hayden Bee Research Center in Tucson, Arizona.

Carpenters, Oxaeids, and Cuckoos

"One bee we're studying for pollinating tomato plants is an Arizona native called a giant carpenter bee. It performs buzz pollination by curling its body around the pollen-bearing anthers," Buchmann says.

Like the fuzzyfoot, the giant carpenter bee "flexes its powerful flight muscles so fast they create sonic energy that causes pollen to shoot out of the tomato flower's hollow anthers. So much pollen is released, it looks like a cloud—enough to pollinate the flower and stick to tiny hairs on the bees.

"We want to develop artificial nests to make mass-rearing of the buzz pollinators possible. The most promising materials seem to be several different kinds of wood and bamboo," says Buchmann.

Buchmann is collecting basic information on wild bees and how the behavior of various species around different crops boosts fruit and vegetable production in fields and in large, commercial greenhouses. He found in one study that a native bumblebee was 500 times faster than the normally reliable honey bee in pollinating flowers of deadly nightshade. This weed is a relative of the tomato plant and native to Arizona, making it convenient for Buchmann to study. He hopes to find the best bee for each type of crop plant.

Buchmann is also learning the best time to move bees into crops and greenhouses. For example, he observed that an oxaeid bee preferred to pollinate between 5 and 6 in the morning, while the bumblebee was a late riser, beginning work after 7 a.m.

And he is recording how various species of buzz pollinators thrive under different temperatures and humidities.

Three carpenter bee species that are native to Arizona seem very hardy, surviving daytime temperatures in excess of 115°F, low relative humidity, and little moisture. These bees could be kept over winter for use year after year, unlike some pollinators that are reared from eggs each spring.

Batra and Buchmann note that bumblebees are now a big business overseas. There are nearly a half-dozen commercial bee producers in Europe rearing 80,000 to 100,000 colonies of bumblebees to use in pollinating tomatoes grown in greenhouses. One Dutch company recently opened a 10-acre tomato greenhouse near Wilcox, Arizona, and uses an estimated 20 bumblebee colonies for pollination. Batra says she's been in contact with a company in Pennsylvania that is beginning to use bumblebees in greenhouses to pollinate tomatoes. Bumblebees are also the only pollinators of potato flowers worldwide.

Another potential blueberry pollinator is *Osmia ribifloris,* says Philip Torchio, an entomologist at the ARS Bee Biology and Systematics Laboratory in Logan, Utah. [See "What's a Better Blueberry Pollinator?," *Agricultural Research,* March 1992, p. 19.] He says the bee—collected in California—visits a blueberry blossom about every 3 seconds—three times as fast as a worker honey bee.

Torchio is planning field studies this spring with *O. ribifloris* on 14 acres of highbush blueberries in Oregon. He says about 300 females are all that's needed to pollinate an acre of blueberries. "We want to demonstrate that it's feasible for growers to raise large

enough numbers of *O. ribifloris* to pollinate their blueberry crop," he says.

Over the last 5 years, lab scientists have also studied 25 endangered plant species and wild bee pollinators in 7 western states. [See "Protecting Endangered Plants," *Agricultural Research,* May 1990, pp. 16-18.] The main objective: to determine how the plants—including rare cacti, wild daisies, and wild snapdragons—are pollinated and which wild bees pollinate each plant. ARS entomologist Vincent Tepedino says researchers found that rangeland spraying to control grasshoppers could further imperil the wild plants by killing their pollinators.

Now Tepedino and cooperators at Utah State University are using molecular genetic techniques to "establish buffer zones to protect these plants and their wild pollinators from grasshopper spraying," Tepedino says.

Aside from development, pollen bees have other enemies, including parasitic "cuckoo bees," which make up about 15 percent of all known bee species. These replace host eggs with their own eggs—like cuckoo birds. They can reduce populations of pollinators, just as cuckoo birds deplete songbird populations.

Batra and cooperators at the Smithsonian and the state universities of California and Florida have also discovered a nematode worm, *Bursaphelenchus abruptus,* that lives inside the glands of a solitary bee called the digger bee. But the nematode may be beneficial to the bee, Batra says.

"In lab studies, the nematode fed on fungi similar to those that infest bee nests and destroy food supplies," she says. "So we think the nematode may act as a natural protector of the bee's food by leaving the glands and destroying the fungus."

But the most important protectors of bees, she stresses, are people. "People need to realize that pollen bees are not a threat, but a wildlife resource—a fascinating, valuable part of our environment."—By **Sean Adams** and **Dennis Senft,** ARS.

SCOTT BAUER

Yellow-dot special: A male carpenter bee, identified by a yellow facial spot, drinks wisteria nectar. The females chew neat, circular holes in wood, where they nest. Territorial males chase each other away from flowers and nests but have no stingers. (K5395-16)

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Philip F. Torchio and Vincent J. Tepedino are in the USDA-ARS Pollinating Insect Biology Research Unit, Natural Resources Biology Bldg., Utah State University, Logan, UT 84322: phone (801) 750-2520/2559, fax (801) 750-1575. ◆

Quick Guide to Pollen Bees

Blueberry bee—*Osmia ribifloris*

Native to the coastal mountains of Southern California, this solitary bee normally gathers pollen from manzanita, but will pollinate blueberries.

Giant carpenter bee—family Xylocopidae

Create so much sonic energy with their buzzing that pollen shoots out of tomato flowers' hollow anthers in a cloud. These native solitary bees nest in bamboo and wood.

Hornfaced bee—*Osmia cornifrons*

Used commercially for several decades in Japan to pollinate apples, it's now in the United States. A single hornfaced bee can visit 15 flowers a minute. This solitary bee nests in reeds, tubes, and holes in wood.

Native bumblebee—*Bombus sonorus*

It's 500 times faster at pollinating than the honey bee. Bumblebees live socially, usually in abandoned underground field mouse nests.

Oxaeid bee—*Ptiloglossa arizonensis*

Prefers to pollinate between 5 and 6 in the morning. This native solitary bee nests underground.

Polyester bees—*colletes* species

Native solitary bees, they build plastic-lined cells in underground nests.

Shaggy fuzzyfoot bee—*Anthophora pilipes villosula*

Fat, shaggy, and fast-flying; it can pollinate in rainy, cool weather. This Japanese solitary bee nests in dry adobe. It was recently imported to the United States.

Sweat bees—family Halictidae

Nesting underground, some kinds form social units with queens and workers.

Chemical Messengers Addle Insect Brains

Imagine trying to find just the right piece of a jigsaw puzzle—while the pieces keep changing their shapes. That was the problem faced by chemist Ronald J. Nachman and entomologist G. Mark Holman in a project begun in 1987 by ARS' Veterinary Entomology Research Unit in College Station, Texas. Collaborating on the project now are scientists at the Scripps Research Institute at La Jolla, California.

Nachman and Holman are studying neuropeptides—chemical messengers sent forth by insect brains to stimulate specific life-sustaining functions—as a possible tool to control or eliminate insect pests. The neuropeptides attach to receptors in an insect's body, much like a key in a lock, to start a desired function, such as molting.

"If we could make artificial versions of these neuropeptides, we might create a compound that fills the receptor and transmits the signal nonstop for the specific function, creating all kinds of havoc in the insect's body," says Nachman.

"Or we might create an antagonist—something that binds to the receptor, but can't turn on the receptor and won't let the natural peptide get in to turn on the receptor."

The chemical messengers are made up of combinations of 20 natural amino acids linked together. "These different amino acids are like letters in words," Nachman explains. "They cause different actions, depending on how you put them together."

In studying the chemical makeup of the neuropeptides, the researchers discovered a family of neuropeptides whose members shared a common chemical core or backbone—"Phe-X-Pro-Arg-Leu-NH2"—with different amino acids filling the X position. This pattern is found in a surprising variety of insects, says Nachman.

For example, among the neuropeptides sharing this common core are a peptide that stimulates cockroaches' hindgut contractions, important in the pests' ability to digest, and another to prompt production of silkworm and corn earworm pheromones, the insects' chemical mating call. These neuropeptides also stimulate contractions of the hindgut and egg-laying organ, or oviduct, of stable flies, which are pests of livestock.

> Surprisingly, one locust neuropeptide was about 100 times more potent for pheromone production in the silkworm than the silkworm's natural neuropeptide.

"We took a natural neuropeptide that causes oviduct contractions in locusts and tested it on silkworms," Nachman notes. "Surprisingly, one locust neuropeptide was about 100 times more potent for pheromone production in the silkworm than the silkworm's natural neuropeptide.

"We've also found a locust neuropeptide that can start diapause, or dormancy, in silkworms. The more physiological processes this neuropeptide family is involved in, the more processes we can disrupt with synthetic substitutes."

But just as knowing the color of a key won't unlock a door, knowing the basic chemical makeup of the peptides was not enough information to build the substitutes.

The researchers also needed a version in the correct shape to fit the insect's receptors. Studying the basic peptide in solution wasn't much help; left floating freely, it thrashed around in a kaleidoscope of configurations.

"So we took the two ends of the peptide and tied them together," Nachman recalls. "We thought that if we restricted its ability to move, it might try to get into its favored position."

The gamble paid off—the peptide bent itself into a saddle shape that fits the insect receptors.

But the struggle isn't over yet. The researchers must still determine the composition and relative importance of the "side chains," chemical compounds attached to the peptide's central "backbone."

"We have to pinpoint the side chains that are important to the activity and then design artificial versions," says Nachman.

"Using a computer, we plan to compare the backbone shape and the chemistry of the side chains with the shape and chemistry of known organic compounds," he explains. "There are certain nonpeptides that can mimic peptides; some are being used as drugs. An example is morphine, which fits into a natural receptor in your brain."

Once the scientists have found substitutes for the natural components of the peptide chain, they will construct artificial versions of the neuropeptide to disrupt the insect's life processes. "We think peptide substitutes could have widespread applications in future pest management strategies," Nachman says.—By **Sandy Miller Hays,** ARS.

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MICHAEL THOMPSON

Native juniper trees encroach on Steens Mountain rangeland, a result of reduced fire frequency, past land use practices, and ideal climatic conditions. (K5408-1)

Harmonizing Rangeland Interests

Technology transfer brings foes together.

As he worked on his latest journal article at the Eastern Oregon Agricultural Research Center in Burns, ARS range scientist Tony Svejcar was frustrated. "I didn't feel satisfied just doing the research and publishing it in a scientific journal. If it wasn't used out on the land, it didn't seem that meaningful," he says.

An unlikely meeting of ranchers, environmentalists, and U.S. Bureau of Land Management (BLM) range conservationists held at the Burns Credit Union in the summer of 1991 solved his problem—and theirs.

At the meeting, they formed the Malheur Lakes Basin Working Group, or MLBWG. A small but growing number of such groups, comprising ranchers and environmental group members tired of meeting in court, is sprouting up around the West.

The argument was over 500,000 acres of public and private land on the north side of Steens Mountain, about 60 miles south of Burns. The mountain supports cattle and a wide variety of wildlife, including bighorn sheep, pronghorn antelope, and sage grouse.

Environmental groups were calling for a national park designation excluding cattle, which would put dozens of ranching families out of business.

Both groups realized the land could be improved—understory grasses used by wildlife and cattle for forage were becoming sparse, and soil was eroding from hillsides. But neither group had facts pinpointing the cause, so they asked Svejcar to bring his scientific perspective to the 12-person MLBWG steering committee. The committee represents hundreds of Oregonians interested in the fate of the mountain, some from as far away as Portland.

One of the major problems turned out to be a natural resident—juniper—growing amok. Oregon State University range scientist Rick Miller, who also works at the ARS/OSU center, was already studying juniper when Svejcar arrived at Burns in 1990.

Miller's research indicates that before settlement, there were only one or two juniper trees per acre. Miller says ideal climate conditions, overgrazing in the early 1900's, and a decline in fire frequency altered the natural balance. Today, 1 acre can contain between 200 and 8,000 juniper seedlings.

Svejcar and Miller believed that the juniper trees were sucking up the available water and nutrients. "Juniper holds its foliage, while the grasses have to regrow leaves every year. As soon as

the soil temperatures get high enough, the juniper starts extracting moisture. Because it uses the moisture before a lot of other species can, juniper creates a drought at the site for everything else," Svejcar says.

To test their theory, they set up eight 2-acre test plots on the mountain, on land provided by rancher Fred Otley. They cut down all the juniper in half of each plot; the other halves were left alone. In the first year, 1992, the cut plots produced twice as much grass as the uncut plots.

In 1993, the end of a 5-year drought brought plentiful rainfall and the difference between the plots was even more dramatic. While uncut plots yielded 30 to 40 pounds of forage per acre, cut plots produced 300 pounds per acre. Grasses, such as basin wild rye, that reached only 3 inches on the uncut plots towered over Svejcar's head on the cut plots.

Cal Brantley, who represents the Oregon Native Plant Society in the MLBWG, says that before the research, most environmentalists didn't believe that juniper was a problem. But when the scientists brought the steering committee members up to the test plots, the committee was convinced. "Everybody at the meeting, including me, stood there looking in awe," he says.

Creating a Vision

Once the group agreed on the problem, the next step was to develop a vision of what they wanted Steens Mountain to look like. "If you don't know what you want to see, you can't design a plan to get there," Svejcar

A Working Vision for Steens Mountain

"We seek to: 1) sustain a stable community which has a healthy, diverse economy that supports a sound infrastructure; 2) develop an atmosphere of respect that fosters open and informative dialogue and trust; and 3) maintain and perpetuate the cultural aspect of rural agriculture, as well as aesthetic values of natural and altered environments."

"We seek to blend environmental and economic needs in a fashion that allows for: clean water, clean air, fish and wildlife, diverse recreational opportunities, profit from livestock ranching and community business, and an aesthetically pleasing environment."—**Malheur Lakes Basin Working Group,** Burns, Oregon.

MICHAEL THOMPSON

ARS range scientist Tony Svejcar (right), Oregon State University range ecologist Rick Miller, and a Steens Mountain working group visit a test plot where juniper trees were cut to encourage growth of forage plants. (K5409-1)

MICHAEL THOMPSON

Controlled burning will restore forage plants squeezed out by juniper invasion. (K54ll-l)

says. Because group members view Svejcar as unbiased, he often serves more than just a scientific role in the group. After the group agreed on basic principles, Svejcar compiled the vision statement. He also served as a liaison to local landowners.

The group turned to BLM, the agency with jurisdiction over public land on the mountain, to convert their vision to a management strategy. This, too, was an uneasy alliance. Neither the ranchers nor the environmentalists trusted the BLM to come up with an acceptable plan and stick to it.

Svejcar says that BLM range conservationists transferred between BLM offices frequently, making it difficult to follow through with management plans. BLM natural resource specialist Mark Sherbourne says the transfer policy was designed to spread the expertise among offices, but now they try to stay in one place longer, for management consistency.

The other problem dogging the BLM was accountability. "The law requires a lot of planning on the front end, in the form of environmental assessments, but it demands no follow-up on the back end," Svejcar says. "Most agencies have money to go out and do projects but not to monitor what they've done to see if it was the right thing or not." Svejcar and OSU researchers will provide that accountability for the juniper project on Steens Mountain. Next summer, BLM, the Nature Conservancy, and the Burns research center will hire college students to sample and monitor several juniper management treatments designed by the researchers, such as cutting and prescribed burning.

MICHAEL THOMPSON

Two years after juniper cuttings, Tony Svejcar inspects regrowth of tall basin wild rye in a Steens Mountain test plot. (K5410-l)

Control plots will be monitored along with the treated areas to measure the success of the program.

An Unexpected Direction

When Svejcar started his ARS career in 1983, he expected to lead the lonely life of a field researcher. "I assumed we were just going to do straight research, and I didn't know how important sharing information—technology transfer—was going to become," he says. "But from a personal standpoint, it's much more satisfying to see the results of your research applied than to just assume that someday somebody's going to use it."

Svejcar says other ARS researchers in fields ranging from range science to genetic engineering would also have things to offer working groups. "It's our responsibility to take the scientific information and synthesize it in a way that can be applied. There are also indirect benefits that we can't easily quantify," Svejcar says, such as increasing public knowledge about environmental benefits from ARS research.

While the process has its critics, those involved believe it can change both the land and the people who live on it. Brantley, of the Native Plant Society, recalls that one rancher wouldn't let him onto his land. "He thought the only thing we were interested in was shutting him down. Now he's joined the society and he's one of my best friends."—By **Kathryn Barry Stelljes**, ARS.

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Seven-Foot Soybeans for Sustainable Silage

At 6 feet, geneticist Thomas Devine stands almost as tall as some of his experimental soybeans.

The plants, 6 to 7 feet tall—twice the height of commercial plants—open the way to a new dairy silage for sustainable farming systems.

"A plant breeder has to be able to see crops not just as they are, but as they can be," says Devine, who is with the Agricultural Research Service's Plant Molecular Biology Laboratory in Beltsville, Maryland.

He says silage soybeans represent a new, different look at the crop's first popular use in this country—as hay. Hay made up 70 percent of the 1924 soybean harvest, though only 3 percent by 1964. "Quality was erratic. The plants dried slowly and rain often leached out nutrients," Devine says.

Those hay-type soybeans were just unimproved lines from Asia, he notes. And while a few farmers today grow soybeans for silage, they use grain varieties. "Most farmers have easy access to silage technology, but no soybeans are bred for silage," he says.

Plants grown for silage are cut, slightly dried, chopped, then enclosed in a chamber such as a bunker or a vertical silo. After natural microorganisms use up the chamber's oxygen, other microbes churn out lactic acid. That pickles the forage into long-lasting, nutritious feed.

"Corn is the number-one silage, but soybeans can potentially produce more protein. And because they're legumes, they would need less commercial fertilizer," Devine says. "Symbiotic bacteria on soybean roots capture nitrogen from the air, and the roots slowly release it as they decay. After harvesting soybean silage in summer, a farmer could plant a small grain, like barley or wheat, and grow it with this 'free' nitrogen."

In 1976, Devine began crossing a hay soybean with grain types showing disease and pest resistance, in cooperative studies with Elwood Hatley at Pennsylvania State University and David Starner at Virginia Polytechnic Institute and State University.

Starner supplied the hay type—a vigorous, leafy, but little-used strain—from Virginia Tech's Northern Piedmont Agricultural Research Station at Orange, Virginia.

SCOTT BAUER

Dwarfed!: Thomas Devine stands among experimental soybean plants over 6 feet tall. They could make highly nutritious silage with loads of digestible protein and require less fertilizer to produce. (K5295-8)

"This spring, we'll begin testing a few of the best experimental lines at several locations for silage yield and nutrient value," says Devine.—By **Jim De Quattro,** ARS.

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Riobravis: Nematode the Magnificent

Ask Enrique Cabanillas what he studies in his Agricultural Research Service lab in Weslaco, Texas, and he'll answer by showing you a refrigerator baggie full of brown mud.

The "mud"—tiny wormlike nematodes in a gel—could make summer a washout for migrating moth pests. About two gallons hold 800 million *Steinernema riobravis* nematodes. That's enough, says the ARS nematologist, to kill more than 90 percent of the corn earworms, fall armyworms, or pink bollworms waiting to emerge from 1 acre of soil as winged adults.

Together, across the United States, the three pests carry an annual price tag estimated as high as $1.3 billion in insecticides and yield loss.

Wiping out an acre's worth of immature corn earworms means about 1,000 adult moths won't fly off to infest up to 70 acres elsewhere, says ARS entomologist Jimmy R. Raulston. He leads the research team that discovered and is testing *S. riobravis* at Weslaco's Subtropical Agricultural Research Laboratory, 7 miles north of the U.S.-Mexico border.

Early each summer, he says, an average of 4.8 billion earworm and armyworm moths migrate from 500,000 acres of corn in the Lower Rio Grande Valley on both sides of the border. They attack corn, cotton, soybeans, tomatoes, and other crops as far as away as Mississippi.

"*S. riobravis* could cut down these migrations," says Raulston, who heads Weslaco's Crop Insects Research Unit. "We didn't even suspect it existed 10 years ago, but it could be available to farmers within 3 years."

ARS scientists are testing the nematode against pests of corn, cotton, and citrus at sites in Texas, Arizona, Georgia, Florida, and Mexico.

It moved quickly towards commercialization under a cooperative research and development agreement between ARS and biosys, a Palo Alto, California, firm.

Biosys commercially produces and markets other beneficial nematodes and supplies *S. riobravis* used in the ARS tests. In 1993, ARS issued licenses to biosys and to Ecogen, of Langhorne, Pennsylvania, to make, sell, and use *S. riobravis,* for which USDA has filed patent applications.

DAVID NANCE

In the bag: Nematologist Enrique Cabanillas lifts a bag containing about 50 million *S. riobravis* nematodes suspended in a gel material. The porous bag is dipped into containers of water, freeing the nematodes into the liquid. (K5142-1)

"Among nematodes," says Cabanillas, "*Steinernema* and *Heterohabditis* species have a unique trait: They carry bacteria. And the nematodes and the microbes need each other to survive."

The nematodes release bacteria after they penetrate an insect larva or pupa. The bacteria kill the insect within about 48 hours. Nematode offspring feed on the corpse and produce a second generation, called infective juveniles.

These nematodes—one-fortieth of an inch long and numbering 300,000 or more—leave to search nearby soil for new prey. Lab tests indicate they can travel several inches during their insect hunt.

Unearthing a Mystery

The story of the nematode's discovery dates to 1984, when Raulston and entomologist Sam D. Pair began studies to learn the size of the moth migrations.

This required unearthing and counting moth larvae and pupae. Many were dead, riddled with nematodes. "But what surprised us," Raulston recalls, "was finding so many naturally parasitized insects year after year."

From 1986 to 1990, Raulston and Pair surveyed about 100 cornfields a year in the Lower Rio Grande Valley. "Nematodes infected earworms in one-third of the fields and fall armyworms in one-fourth," Raulston says. "Furthermore, nematodes accounted for about half the dead specimens we found. At that point we realized the nematodes might have potential as biocontrols farmers could use."

Raulston and Pair speculated the nematode was a *Steinernema,* probably *S. feltiae*—but no *Steinernema* were known to occur in the area. The scientists knew, however, that their mystery nematode was a tough hombre.

"Most of those cornfields are cropped only once a year, and long periods of drought and high heat are common. So the nematode had to be able to survive a long time outside an insect host," says Raulston.

To pin down its identity, Cabanillas joined the Weslaco research team in 1990. "Under a microscope," he says, "*S. feltiae* and other nematode species may look alike at first glance." But he ruled out *S. feltiae* after he couldn't get the unidentified nematode to cross-breed with it—or with three other known *Steinernema* species. This and morphological and genetic differences uncovered by Cabanillas and colleagues in Australia and California proved their nematode was new. They named it for the Rio Bravo, the Mexican name for the Rio Grande, in 1993.

DAVID NANCE

Letting 'em loose: A laboratory-prepared solution of *S. riobravis* nematodes is added to irrigation water by technician Orlando Zamora. The pest-controlling nematodes are carried by water along the rows and seep into the soil. (K5142-2)

A Tactic That Can Take the Heat

ARS lab and field studies have largely answered the most important questions for farm use of *S. riobravis:* application rates and methods, numbers of infective juveniles per cycle, the nematode's in-soil travel rate—and its ability to tolerate hot summers.

"*S. riobravis* can really take the heat," says Thomas Henneberry, director of ARS' Western Cotton Research Laboratory in Phoenix. "Summer soil temperatures here often exceed 100°F. But last July, we found infected pink bollworms 21 days after applying *S. riobravis* in simulated irrigation experiments."

Henneberry hopes the nematode can hold down the cost of pink bollworm for California and Arizona cotton growers. "In one recent season, chemical insecticide just for pink bollworm averaged $260 per acre. That was 23 percent of all cotton production costs in the two states," he says.

But the soil-dwelling nematodes exploit the pest's major weakness. All winter, immature pink bollworms hole up under the soil surface or in cotton "trash."

Using nematodes against this generation could undermine the moths' season-to-season bridge. With fewer moths emerging, they are far less able to breed their usual 4 to 12 successively larger and more destructive generations during the season.

Phoenix scientists and colleagues compared *S. riobravis* with other beneficial nematodes—for heat tolerance, ability to infect, and ability to wriggle through soil. Overall, the new nematode performed 20 times better than *S. carpocapsae* and 10 times better than *Heterohabditis bacteriophora.*

Last spring, Henneberry says, nearly 100 percent of pink bollworm larvae died within 48 hours after nematodes were applied to outdoor test plots in irrigation water.

It appears the nematode's usefulness may extend beyond the Southwest. ARS scientists ran its first tests in the Southeast last year, against corn earworm in Georgia and root weevils and other weevil pests of Florida citrus.

Says Raulston, "We think *S. riobravis* may be able to control other pests, such as black vine beetles, mole crickets, wireworms, root maggots, diamondback moths, sweetpotato weevils, carrot weevils, beet armyworms, and cabbage loopers."—By **Jim De Quattro,** ARS.

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Tomatoes and Potatoes: More in Common Than Meets the Eye

If you put a tomato and potato side by side, they don't appear to have much in common. But the plants that produce them actually look very much alike and have such similar genetic backgrounds that they should be grouped in the same plant genus.

That recommendation comes from U.S. Department of Agriculture and university scientists who collected wild potato and tomato plants and compared their genetic makeups. David Spooner, a scientist with USDA's Agricultural Research Service in Madison, Wisconsin, says tomato and potato plants are not considered by most people to be related, because the parts that are eaten appear to be so different. It's not the fruits but the tubers that grow on potato roots that are so widely valued as a dietary staple.

"But in South America, it's not unusual to find a cherry tomato-size fruit growing on wild potato plants," says Spooner, a botanist in the agency's Vegetable Crops Research Unit in Madison. "And wild tomatoes have small fruits that may never turn red and that have a color and shape similar to many wild potato fruits."

Potatoes are now taxonomically placed in the *Solanum* genus; tomatoes in *Lycopersicon*.

Spooner, Gregory J. Anderson of the University of Connecticut, and Robert K. Jansen of the University of Texas believe that tomatoes belong in *Solanum.* They reported their findings in an *American Journal of Botany* article about two of the world's most popular vegetables.

Spooner says the researchers' findings were based on an examination of DNA from chloroplasts of 21 *Solanum* species, three *Lycopersicon* species, and three other related genera. Chloroplasts are green structures in plant leaves that contain chlorophyll, which is involved in plant photosynthesis.

By comparing markers for certain genes, he says, the scientists were able to match those genes among the various species—allowing them to establish how closely related potatoes and tomatoes are. They also based their finding on morphological traits such as the flowers and the form of the overall plant.

Originally, Swedish biologist Carl Linnaeus, in 1753, placed tomatoes in *Solanum,* but another scientist later moved them into *Lycopersicon*. Scientists have debated the issue ever since.—By **Sean Adams,** ARS.

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A Better Amylose Test? Thank the Guy Down the Hall!

High-amylose corn, with starch that's about 50 to 75 percent amylose, has been around a long time. It's a specialty grain developed for the food coatings industry more than 30 years ago.

But millers are paying more attention to this grain now, thanks to the recent development of amylose-based fat substitutes.

Unfortunately, analytical technology has lagged behind this increased demand. As a quality control measure, companies exporting, or using the corn, and corn breeders have for some time needed a quick test to measure amylose.

So, the Illinois Corn Dry Millers Federation decided the subject should be discussed at an annual meeting held at the National Center for Agricultural Utilization Research in Peoria. At the meeting, ARS chemist Clarence A. Knutson shared an analytical technique he had developed for his research in the mid-1980's.

A member of the federation responded that the technique was promising—but not good enough. Samples had to be cooked and soaked overnight in a solution of iodine and dimethylsulfoxide. Then a spectrophotometer measured the amylose content by gauging the intensity of blue caused by reaction of the iodine with the starch.

The test still wasn't exactly fast. So, back to the lab hurried Knutson, intent on speeding up the process.

First he added calcium chloride to samples to gelatinize the starch at room temperature.

At this point, uncertain how much improvement he could expect, Knutson accepted some advice from a chemist from down the hall, Frederick R. Dintzis, who casually suggested, "Why not try sonicating the samples?"

Sonication—vibrating with soundwaves—struck a chord with Knutson. He gave it a try.

By sonicating to separate starch molecules from each other and from other materials, and by adding calcium chloride, Knutson was able to complete analysis of cornstarches in less than 1 hour.

At the next corn millers meeting, in 1993, the persistent chemist presented his success.

Dave Kemmerer who works for Identity Seed and Grain Company, Bloomington, Illinois, says use of the improved method to test inbred and hybrid corn for amylose "allows us to provide smaller samples for testing than required by a previous method."—By **Ben Hardin**, ARS.

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MIMI WILLIAMS

Senepol cattle. (K3714-4)

Senepols Keep Their Cool

The word's been spreading for at least a decade: Senepol cattle can stand hot weather just as well as Brahmans, offering a long-awaited breeding alternative for livestock growers in subtropical settings. Only one thing was missing—proof.

Now Andrew C. Hammond has the numbers. Hammond and University of Florida researcher Tim A. Olson began a 3-year evaluation in 1988 at the ARS Subtropical Agricultural Research Station at Brooksville, Florida, comparing heat tolerance capabilities of Senepol, Brahman, Angus, and Hereford cattle. Their findings: Senepols are superior at keeping their cool.

"The real essence of heat tolerance is an animal's ability to maintain normal body temperature under heat stress," says Hammond. "For cattle, normal is about 102°F."

In one experiment, Hammond and Olson measured rectal temperatures of 120 cows—30 each of Senepol, Hereford, Angus, and Brahman cattle on 5 days in June, July, and August. The Senepol cows' mean temperature over the five measurement dates was 102.1°F, compared with 102.7°F for the Brahmans, 102.9°F for the Herefords, and 104.4°F for the Angus.

While calves' temperatures are normally a little higher than those of mature animals, in a 1990 study, Senepol calves were still the coolest, with a mean temperature of 103.3°F. Calves that were half Hereford and half Senepol hovered around 103.5°F, and the mean temperature for Hereford calves was 105°F.

Mindful of the Senepols' shorter hair coat, the scientists sought to offset that natural advantage by giving some of the Hereford calves a summer haircut about halfway through the 1990 study.

The clipped Hereford calves' rectal temperatures wound up lower than their hairy brothers, but the Senepols were still the lowest, suggesting the Caribbean cattle's coolness is based on more than short hair.

"The difference in these temperatures between breeds may not seem that great, but it's like a human going from a normal temperature of 98.6°F to 100°F," explains Hammond. "That's not a big difference, but you'd already be uncomfortable."

Discomfort can translate into lost opportunity for cattle producers. In another study, Hammond and Olson found Senepol cows grazed 10.7 hours per day, compared with 9.3 hours for the Herefords.

"The more cattle eat, the more they produce," says Hammond. "The hypothesis is: If the Senepol are grazing an extra 90 minutes a day, their forage intake is greater."

Senepols have been a hot topic at Brooksville since 1978, the year the station's first Senepol-sired calves were born. Senepols were first bred in 1918 on St. Croix in the Virgin Islands and are a blend of the English Red Poll and African N'Dama breeds. They are of medium build with a glossy, deep-brown coat and a small neck wattle.

Before the arrival of Senepols in this country, U.S. cattle producers crossbred their herds with Zebu-type cattle such as Brahmans to boost the animals' heat tolerance and disease resistance. But the Brahmans, of the *Bos indicus* species, carried some drawbacks along with their characteristic hump, including poor reproductive efficiency, an unpleasant disposition, and reportedly tougher meat.

Despite their tropical adaptation, Senepols are *Bos taurus* animals, the same species as Angus, Hereford, and other English cattle breeds.

"In preliminary experiments, Senepol had carcass quality more like other *Bos taurus* animals than like the Brahman," says Hammond. "Also, their temperament is much more docile, more like a Hereford. On the other hand, under the nutritional conditions we have here in central Florida, their reproductive efficiency is not much better than that of the Brahman.

"There are quite a few Senepol breeders now in southern coastal states—Texas, Alabama, Georgia, North and South Carolina, and Virginia—and inland, in Tennessee and Kentucky," Hammond adds. "But Senepols are still a minor breed in the United States. Their greatest potential will probably be in crossbreeding programs, providing herds with adaptation to a hot, humid environment."—By **Sandy Miller Hays,** ARS.

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Lysimeters Bridge Lab and Field Tests

Movement of contaminants into groundwater supplies can be more accurately studied with an inexpensive new weighing lysimeter developed at the Agricultural Research Service's U.S. Salinity Laboratory in Riverside, California. Research lysimeters are large, instrumented tanks filled with soil.

But four new aboveground types are now providing scientists more accurate data than older, ground-level units on the movement of chemicals and trace elements such as arsenic, molybdenum, and boron through soil.

"We are now using them to validate how well computer models assess the movement of soluble chemicals such as fertilizers, pesticides, naturally occurring trace elements, and heavy metals so they don't become pollutants," says Dennis L. Corwin, ARS soil scientist who developed the lysimeter.

"We need more information and credible models to allow environmentalists and legislators to develop guidelines and legislation that appropriately protect ground and surface water supplies," says James D. Rhoades, director of the laboratory.

"The new lysimeters will make acquisition of accurate information easier, permitting model development and testing at a more reasonable cost."

Lysimeter tests are used as a bridge between results obtained in laboratory studies and those from research conducted on actual fields.

The aboveground lysimeters cost about $4,000 and can replace less accurate in-ground ones costing 5 to 10 times more. They are made from upended pieces of PVC plastic pipe, about 2 feet in diameter, 6 feet long, with 1/2-inch-thick walls. The pipe is surrounded by a plywood box filled with foam insulation.

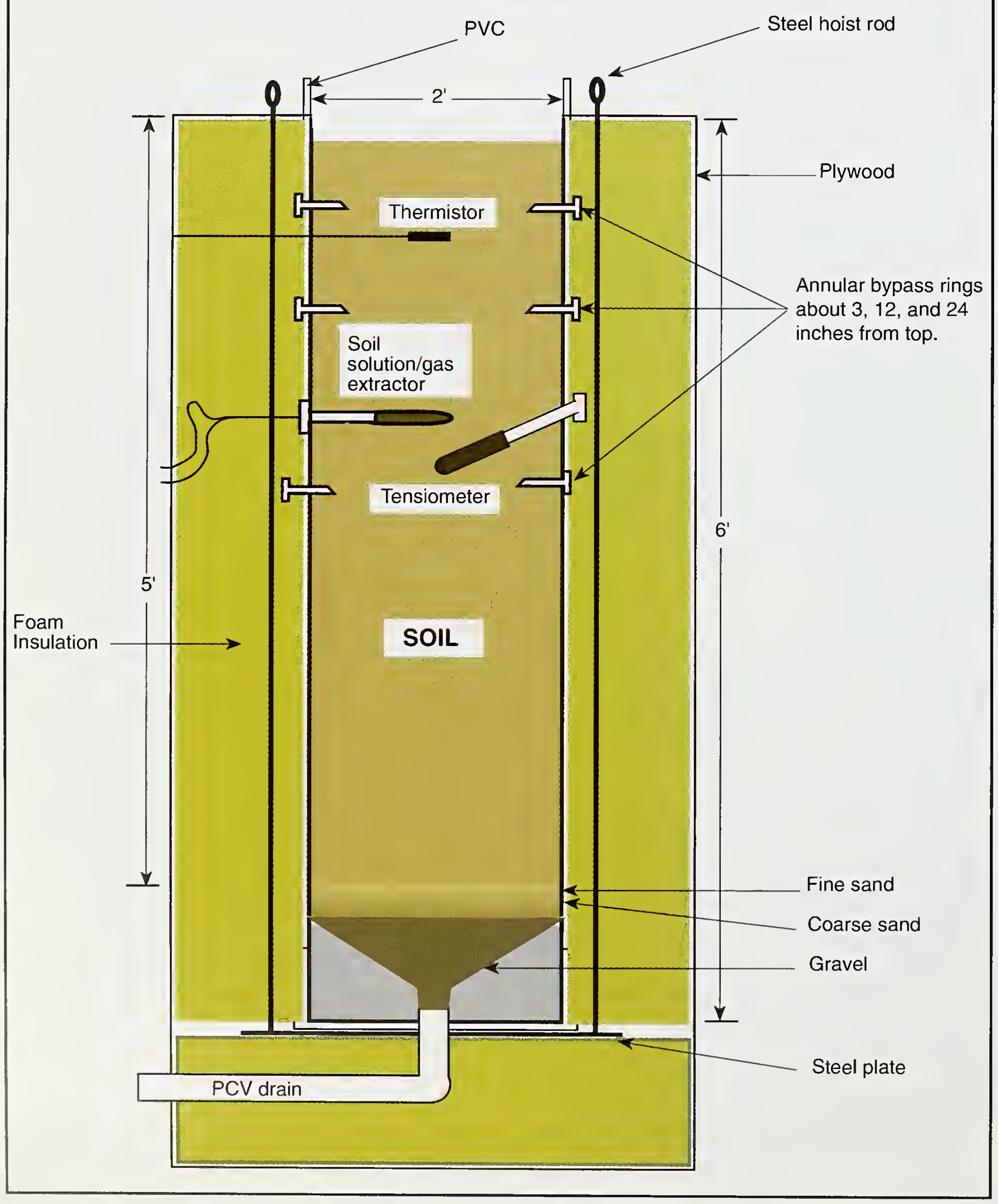
Scientific instruments built into the lysimeter from the side measure water content and temperature and can yield water and gas samples throughout its entire volume.

A key factor in obtaining better data is three V-shaped plastic rings that attach to the inside of the lysimeter column. Spaced from the top at about 3-, 12-, and 24-inch depths, the rings act as baffles to divert waterflow from along the inside of the column back into the soil sample.

Many soils tend to shrink away from the lysimeter wall, and older models allowed a major part of the water and chemicals to flow downward in cracks that form between the column wall and soil sample. This relatively rapid flow did not encounter the same degree of retardation, chemical adsorption, and biological degradation as normally occurs when fluids seep slowly through soil.—By **Dennis Senft,** ARS.

Dennis L. Corwin and James D. Rhoades are at the USDA-ARS U.S. Salinity Laboratory, 4500 Glenwood Dr., Riverside, CA 92501; phone (909) 369-4819, fax (909) 369-4818. ◆

ABOVEGROUND LYSIMETER
(not to scale)



Science Update

Fungus May Defang Medusahead

A fungus might be the hero needed to slay a western range weed named for the snake-haired Greek monster. Millions of small but spreading infestations of medusahead crowd out native forage plants in the Great Basin—between the Cascade, Sierra, and Rocky Mountains. Dry medusahead's golden, fanglike barbs lacerate the mouths of grazing animals. The weed also fuels wildfires. ARS and Montana State University scientists are testing a *Fusarium culmorum* fungus. It rots the crown of the weed, reducing its growth and keeping it from reproducing. *Paul Quimby, Jr., USDA-ARS Rangeland Weeds Laboratory, Bozeman, Montana; phone (406) 994-6850.*

JIM YOUNG

Medusahead.

Cattle Make Rangeland Safer for Sheep

On western range, cattle are protecting sheep from coyotes. Scientists found that temporarily putting heifers and ewe lambs together in small paddocks forges strong social bonds between the two species. Later, when they graze together, coyotes keep their distance. More than once, the scientists have seen a cow face down a coyote and force it to beat a hasty retreat. Plus, the two species' different grazing habits make for a more balanced use of rangeland plants, so overgrazing of key species is less likely. *Dean M. Anderson, USDA-ARS Jornada Experimental Range, Las Cruces, New Mexico; phone (505) 646-4842.*

Flea Debris Can Trigger Allergy Flare-Ups

It's long been known that when fleas bite, they deposit allergen-carrying saliva in the bloodstream. Now, scientists at ARS and the University of South Florida have discovered other sources of flea allergens. They've identified two allergenic proteins in flea debris—castoff material such as flea egg shells and skin. In a medical study by university scientists, 6 of 48 people predisposed to allergies tested positive for reaction to the two proteins. As flea debris accumulates—for example, in places where pets sleep—it can become part of the allergen load in household dust. Inhaling flea debris can cause an allergic person to have watery eyes, itching, or other symptoms. *Richard J. Brenner, USDA-ARS Medical and Veterinary Entomology Research Laboratory, Gainesville, Florida; phone (904) 374-5937.*

"Overfishing" Can Deplete Immune System

People are health-wise to include plenty of fish in the diet. The high levels of omega-3 fatty acids may help prevent or ease atherosclerosis and inflammatory diseases. But we should avoid going overboard, according to a 24-week ARS study with 22 volunteers. The study suggests that eating fish every day for a long time may weaken the immune system. While there is no direct evidence that a fish-diet-related drop in immune response raises the incidence of infectious disease, the finding is based on indirect signs. They include test-tube assays showing slower multiplication of disease-fighting white blood cells and a 46 percent weaker response to antigens administered as a skin test. *Simin N. Meydani, USDA-ARS Human Nutrition Research Center on Aging at Tufts, Boston, Massachusetts; phone (617) 556-3129.*

Bean Beetles Have Little Use for New Soybean

In many parts of the Midwest, leaf-chomping Mexican bean beetles are soybean's major insect foe. But immature bean beetles apparently can't stomach a new soybean breeding line. Natural chemicals in the leaves slow larval growth. In greenhouse tests, no larvae developed into adults. Breeders can use the new line, HC83-193, to create new commercial varieties. ARS developed it in cooperation with the Ohio State University and Ohio Agricultural Research and Development Center. It yields more, matures earlier, and has higher quality seed than other breeding lines of pest-resistant soybeans. *Richard L. Cooper, Corn and Soybean Research, Wooster, Ohio; phone (216) 263-3875.*

New Diagnostic Test for Foreign Swine Disease

ARS scientists developed a new diagnostic test for VESV—or vesicular exanthema of swine virus. This virus was eradicated from the United States more than 30 years ago, but another virus indistinguishable from it has been isolated from marine mammals and fish along the West Coast. If VESV reappears in U.S. pigs, the new test could reduce losses to the industry. *Roger D. Woods, USDA-ARS National Animal Disease Center, Ames, Iowa; phone (515) 239-8358.*

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Upcoming in the MARCH Issue

- Nonchemical tactics against boll weevils may soon supplant insecticides as the weapon of choice of U.S. cotton growers, saving them up to $200 million annually.
- Hillside barriers of perennial grasses create natural terraces that protect soil from erosion and increase farm productivity.
- Baits, traps, and zappers—combined in an intensive fly-control system—can help farmers and suburbanites be friendlier neighbors.